Alberta Energy Regulator | AGS ALBERTA GEOLOGICAL SURVEY

Rare-Earth Element Potential in Alberta

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1. Rare-Earth Elements

Rare-earth elements (REEs) have a wide range of uses in advanced technological applications and, as a result, have been included in the critical minerals lists of many countries, including Canada (Government of Canada, 2024). Rare-earth elements and 16 other Canadian critical minerals are considered prospective in Alberta (Alberta Geological Survey, 2025a).

2. Alberta Highlights

In Alberta, REEs occur in several geological deposit types and in industrial waste streams where industrial processing has increased REE concentration beyond that of the original geological input material (Figure 1):

1. oil sands froth treatment tailings
2. coal fly ash
3. pegmatites and granitoids of the Canadian Shield in northeastern Alberta
4. metalliferous black shales of the Western Canada Sedimentary Basin
5. sedimentary phosphate-bearing rocks in the mountains and foothills of southwestern Alberta

Near Fort McMurray, oil sands processing can concentrate between 43.6 and 72.5 kt per year of monazite, a rare-earth-element–bearing mineral, in froth treatment tailings. In the Canadian Shield in Alberta, occurrences have been discovered with concentrations up to 10 890 ppm total rare-earth elements (TREEs). In the Birch Mountains, metalliferous black shales contain historical inferred resources of 534.1 kt of total rare-earth oxides (TREO).

Table 1. Production of bitumen and estimated concentration of monazite in oil sands froth treatment tailings (FTTs) based on 2024 annual reported production values (Alberta Energy Regulator, 2025).

Producer/Mine	Processed Ore[a] (Mt)	Estimated FTTs[a] (Mt)	Estimated Monazite[b] (kt)
CNRL / Horizon	186.7	2.65	8.0–13.3
CNUL / MRM + JPM	171.5	2.43	7.3–12.2
Suncor / Fort Hills	113.9	1.62	4.9–8.1
Imperial / Kearl	166.0	2.36	7.1–11.8
Suncor / Millennium +North Steepbank	159.1	2.26	6.8–11.3
Syncrude / Mildred Lake+ Aurora North	222.2	3.16	9.5–15.8
Total	**1019.4**	**14.48**	**43.6–72.5**

[a] Based on the Alberta Chamber of Resources (1996) calculation of 1.42% yield from mined and processed ore (Alberta Energy Regulator, 2025)
[b] Estimated from a monazite concentration of 0.3–0.5% in the heavy mineral fraction of FTTs (Alberta Chamber of Resources, 1996)
Abbreviations: CNRL, Canadian Natural Resources Limited; CNUL, Canadian Natural Upgrading Limited; Imperial, Imperial Oil Limited; JPM, Jackpine mine; MRM, Muskeg River mine; Mt, million tonnes; Suncor, Suncor Energy Inc.; Syncrude, Syncrude Canada Ltd.

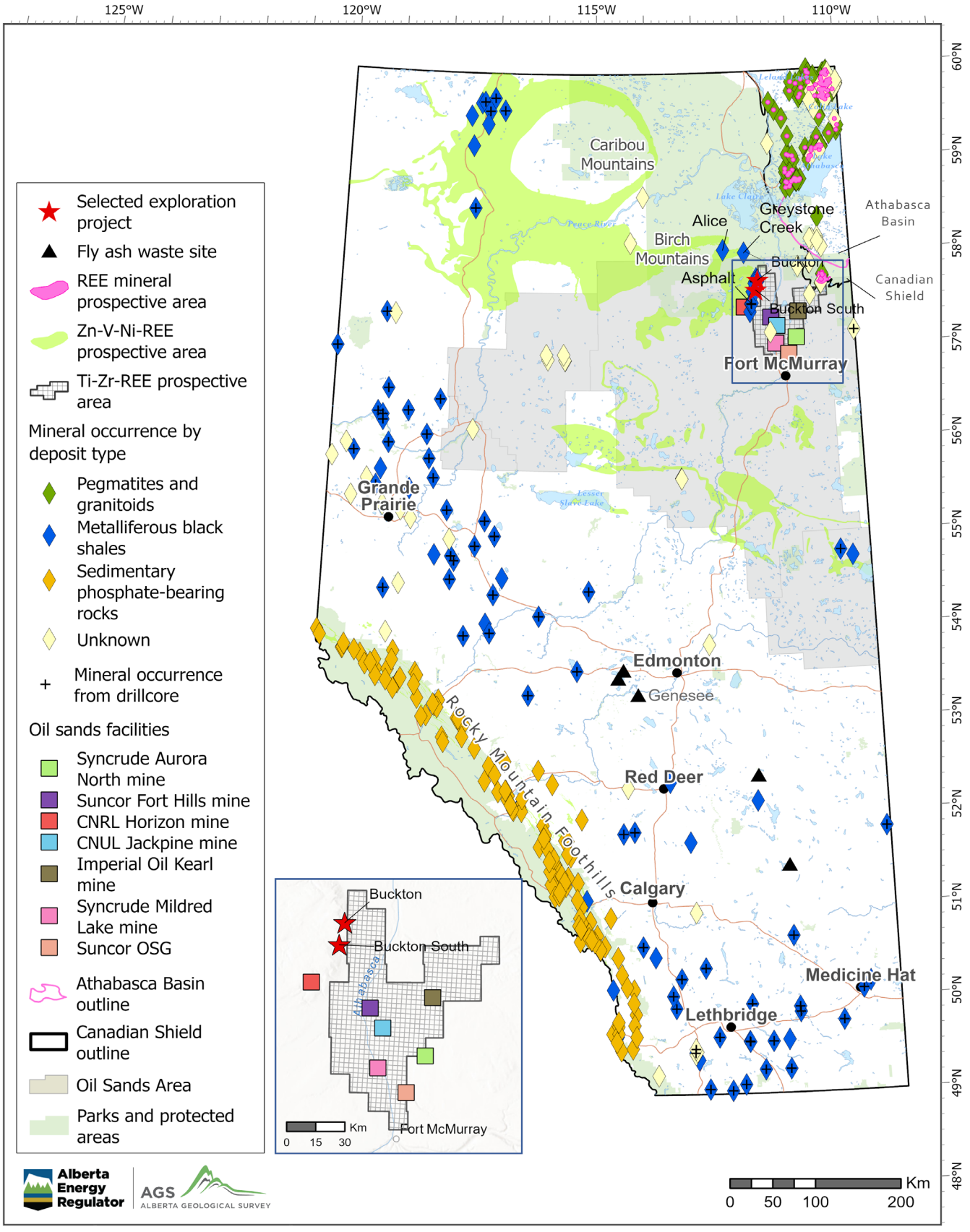
2.1 Oil Sands Froth Treatment Tailings

There is significant potential for REE extraction from froth treatment tailings (FTTs) generated from processing oil sands ore in northeastern Alberta (Table 1). The REEs in FTTs are primarily hosted within monazite, a phosphate mineral that also contains variable quantities of thorium. During oil sands processing, the heavy mineral fraction is concentrated within the FTTs. Oil sands ore initially contains 0.25–0.5% heavy minerals (Ciu et al., 2003), which is concentrated to 15–30% in the FTTs (Chachula and Erasmus, 2008). Based on a monazite concentration in the heavy mineral fraction of FTTs of 0.3–0.5% (Alberta Chamber of Resources, 1996), oil sands operations can concentrate approximately 43.6 to 72.5 kt of monazite per year (Moran, 2025; Z. Burkus and M.B.K. Belosevic, work in progress, 2026). Estimates of monazite tonnage, and concentration of REEs within monazite will likely change with the introduction of modern, standardized geochemical analysis of FTT samples. Such data is currently scarce.

2.2 Coal Fly Ash

In Alberta, coal fly ash was produced from burning sub-bituminous coal in power plants that are now mostly shut down or converted to natural gas. While average REE concentrations in coal fly ash are low compared to traditional hard rock REE resources, the more economically attractive REEs (Nd, Eu, Tb, Dy, Er, and Y) are relatively enriched (Li et al., 2020). Coal fly ash with at least 1000 ppm REE oxides is considered prospective (Dai and Finkelman, 2017). In Alberta,

Figure 1. Location of oil sands operations, and rare-earth element (REE) occurrences and deposits in Alberta, and outlines of the Canadian Shield and Athabasca Basin in northeastern Alberta with an inset map showing the oil sands operations in more detail (Alberta Geological Survey, 2025b; Morley et al., 2025).
Abbreviations: CNRL, Canadian Natural Resources Limited; CNUL, Canadian Natural Upgrading Limited; Imperial Oil, Imperial Oil Limited; Suncor, Suncor Energy Inc.; Syncrude, Syncrude Canada Ltd.



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coal fly ash from the Genessee mine was characterized by Gupta et al. (2019) as containing up to ~1399 ppm of REE oxides. As fly ash from coal-burning power plants is not currently being generated in Alberta, this resource is not growing. Additionally, the current use of coal fly ash in cement production will steadily deplete this resource.

2.3 Pegmatites and Granitoids of the Canadian Shield in Northeastern Alberta

A total of 188 REE surface occurrences have been reported in pegmatites and granitoids of the Taltson basement complex and the Taltson magmatic zone across the Canadian Shield in Alberta (see Table 2 for select occurrences). To date, most exploration in the area has focused on its uranium potential, though more recently these geological units have been reevaluated for their potential to host other critical elements such as REEs and thorium.

2.4 Metalliferous Black Shales

Highly metalliferous black shales have a combined metals (Mo+Ni+Se+V+Zn) concentration greater than 1500 ppm (Johnson et al., 2017). In Alberta, there are 94 identified occurrences of highly metalliferous black shales, 82 of which were identified in drillcore from the Western Canada Sedimentary Basin and 12 in outcrops (Morley et al., 2025). Thirty-six of these occurrences contain elevated rare-earth element contents (See Table 3 for select occurrences). There are two historical inferred resources in the Birch Mountains region of northeastern Alberta, which included elevated concentrations of several commodities, including MoO_3, Ni, V_2O_5, Zn, Cu, Co, Li_2CO_3, U_3O_8, REO, Y_2O_3, and Sc_2O_3 hosted within the Upper Cretaceous Second White Specks and Labiche (Lea Park) formations. Other identified occurrences of REEs in metalliferous black shales have been reported in the Devonian–Mississippian Exshaw and Lower Cretaceous Loon River formations.

2.5 Sedimentary Phosphate-Bearing Rocks in Southwestern Alberta

Sedimentary phosphate-bearing rocks are present in southwestern Alberta along the Rocky Mountains and Rocky Mountain Foothills in the Exshaw Formation, the Permian Johnston Canyon and Ranger Canyon formations, and the Jurassic Fernie Formation (Macdonald, 1987). Macdonald (1987) reported REE concentrations in both the Exshaw and Fernie formations and found they contained average REE concentrations of 752 and 772 ppm, respectively. Emsbo et al. (2015) found that REE extraction from phosphate-bearing rocks is simpler than traditional hard rock extraction which improves the economic outlook of relatively low-grade occurrences.

Table 2. Summary of select rare-earth element (REE) occurrences in the Canadian Shield in northeastern Alberta.

AGS Occurrence ID[a]	Location	Geological Unit	Lithology	TREEs[b,c] (ppm)	Source
074L 0081	Lake Athabasca north shore	Chipewyan granite	Gneiss	10890*	Dahrouge and Smith (2007)
074L 0208	Lake Athabasca north shore	Wylie Lake granodiorite	Gneiss	10739*	Dahrouge and Smith (2007)
074E 0019	Marguerite River	Marguerite River complex	Banded granitoid	6620*	Dufresne et al. (1994)
074M 0266	Bonny Fault	Rutledge River complex	Metasedimentary rock	5965*	Smith and Griffith (2007)
074M 0262	Bonny Fault	Taltson basement complex	Sheared gneiss	4082*	Smith and Griffith (2007)
074M 0240	Cherry Lake	Colin Lake granitoid	Pegmatite	2218*	Smith and Griffith (2007)
074M 0253	Andrew Lake	Taltson basement complex	Pegmatite	2233*	Smith and Griffith (2007)

[a] Unique identifier specific to Morley et al. (2025)
[b] Total rare-earth elements, not including scandium or yttrium
[c] The full suite of REEs were not analyzed and/or reported. These values are considered minimums.

Table 3. Summary of REE resources and select occurrences in metalliferous black shales.

Name	Location	Stratigraphic Unit (formation)	Description	Recoverable TREO[a] Historical Inferred Resource (kt)	Recoverable TREO[a] Historical Indicated Resource (kt)
Buckton zone[b]	Birch Mountains	Second White Specks, Labiche (Lea Park)	Mineral deposit (partially within wildland provincial park)	472.6	28.5
Buckton South zone[c]	Birch Mountains	Second White Specks, Labiche (Lea Park)	Mineral deposit	61.5	No estimate
Asphalt zone[d]	Birch Mountains	Second White Specks, Labiche (Lea Park)	Two boreholes intersected 7.2–11.4 m thick mineralized horizon	No estimate	No estimate
Alice[d]	Birch Mountains	Second White Specks	Sample with REEs of up to 2493 ppm REEs not including Pr, Gd, Dy, Ho, Er or Tm	No estimate	No estimate
Grey-stone Creek[e]	Birch Mountains	Second White Specks	Sample with up to 1128 ppm REEs, not including Pr, Gd, Dy, Ho, Er, or Tm	No estimate	No estimate

[a] Total rare-earth element oxides, including Y_2O_3 and Sc_2O_3
[b] Dufresne et al., 2011; Eccles et al., 2012a, b; Eccles et al., 2013a, b; Puritch et al., 2013

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